Municipal Paving

A SYMPOSIUM

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NEW YORK CITY

By P. C. WILSON, New York.

The work of paving streets and highways in the City of New York is under the jurisdiction of the various borough presidents. Specific information in the following report refers to the Borough of Manhattan, general information refers to the City of New York.

Public notices for proposals in the matter of contracts must be advertised at least ten days in the *City Record* and in the corporation newspapers. The corporation counsel settles the terms of the contract as an act of preliminary specification to the bid or proposal.

Bids are publicly opened by the borough president in the presence of the comptroller, whose absence, however, does not postpone the opening of the bids. If the successful bidder fails to accept the contract within five days after written notice that it has been awarded to his proposal, or if he fails to give proper security and to execute the contract, it shall be readvertised and relet.

The borough president has independent power to award the contract to the lowest bidder. In order to award the contract to other than the lowest bidder, the borough president must secure a three-quarters vote of the board of estimate and apportionment, of which board he is a member, that it is for the public interest to make such award.

The adequacy and sufficiency of the security bond of the successful bidder must be approved by the comptroller. No bid is ever awarded to any person in arrears to the City of New York upon debt or contract, or who is a defaulter upon any obligation to the city.

MILEAGE OF PAVEMENTS, BOROUGH OF MANHATTAN, JAN. 1, 1907.

	Sq. yards.	Miles.
Specification granite	2,013,447.56	50.10
Square granite	94,076.7	4.21
Specification trap	399,513.3	22.74
Belgian trap	292,647.77	14.24
Sheet asphalt	5,004,329.8	248.46
Block asphalt	713,188.6	31.57
Cobble	3,304.9	.79
Wood block	163,258.6	7.69
Macadam	727,351.8	13.65
	9,411,119.03	393.45

The general tendency, within the last five years, has been to reduce the mileage of macadam, cobble, specification granite, square granite, specification trap and Belgian trap pavements, and to increase the mileage of asphalt sheet, block asphalt and creosoted wood block.

AVERAGE PRICES, BOROUGH OF MANHATTAN, CITY OF NEW YORK.

Asphalt Sheet.

Year.	Period of maintenance.	Sq. yd. pavement.	Sq. yd. stone foundation.	Cu. yd. concrete.	Curb.	Sewer and water head.	Avg. price including all items of cost
1901....	10 yrs.	$2.08	$0.48	$6.55	$0.76	$24.00	$3.73
1901....	5 "	2.44	0.40	6.15	0.69½	....	....
1902....	5 "	1.12	0.33	....	0.57½	20.51	1.95
1903....	5 "	1.16	0.31	5.40	0.59½	20.00	2.27
1904....	5 "	1.22	0.35	3.50	0.73	20.10	2.13
1905....	5 "	1.07	0.26	5.20	0.58	16.10	1.54
1906....	5 "	1.08	0.27	4.83	0.55½	14.72	1.66

Asphalt Block.

Year.	Period of maintenance.	Sq. yd. pavement.	Sq. yd. stone foundation.	Cu. yd. concrete.	Curb.	Sewer and water head.	Avg. price including all items of cost
1901....	5 yrs.	$2.58	....	$6.84	$0.77½	....	....
1902....	5 "	1.73	....	5.93	0.67	$24.00	$2.98
1903....	5 "	1.75	....	6.15	0.72	....	2.93
1904....	5 "	1.72	....	6.47	0.78	24.04	3.15
1905....	5 "	1.60	....	4.60	0.60	15.00	2.49
1906....	5 "	1.56	....	4.89	0.57½	14.82	2.36

Granite Block.

1902....	1 yrs.	$2.29	....	$3.93	$0.48	....	$3.49
1903....	1 "	2.48	....	4.90	0.45½	....	3.44
1904....	1 "	2.76	....	4.36	0.63½	....	3.59
1905....	1 "	2.51	....	4.42	0.58½	....	3.23
1906....	.....	2.38	....	4.02	0.47½	....	3.55

Wood Block.

1904....	5 yrs.	$2.39	....	$6.18	$0.69½	$20.00	$3.87
1905....	10 "	2.24	....	6.07	0.64	16.00	4.10
1906....	10 "	2.76	....	6.12	0.66	15.43	4.45

There is no reason for the excessive price of concrete foundation for wood block pavement. There is a practical monopoly in the City of New York for the laying of this pavement. The cost of pavements in the Borough of Manhattan is increased on account of the numerous subsurface structures, necessitating during the year 1906, 32,951 openings in the surface of street pavements. The profit on the restoration of such openings is sufficient to tend towards a reduction in the bid of an asphalt company which provides for a maintenance period of five years. Unusually heavy traffic in the Borough of Manhattan tends to increase the restoration, due to wear and tear, and therefore has an opposite influence on the matter of cost under a five year maintenance contract. The chief engineer of the bureau of highways for the Borough of Manhattan in his report for the year 1906 states as follows:

"There has been maintained, under contract, and where the original guarantee of maintenance has expired, 690,000 square yards of pavement on which 160,000 square yards of repairs have been made at a cost of thirty-four cents per square yard per year. The same work in Brooklyn costs seven cents per square yard per year, the increased cost in Manhattan being due to the unusual traffic conditions and the large amount of street opening, the contract prices being as low as those in Brooklyn."

The electric trolley-slot and the old strap rail both hasten the destruction of pavements. Concrete foundations of not less than five inches in depth, topped by a binder of at least one inch in depth are preferred to the relaying of old granite blocks, for the reason that the latter is unstable, and that sinkages and rocking occur where the pavement is replaced over cuts.

On a small contract one inspector is assigned. On a larger contract two or more are assigned, depending upon the number of points at which work

is being prosecuted. An inspector is assigned to concrete work, and one to the laying of asphalt, on all large contracts; occasionally one is also appointed to supervise the laying of curbing. These inspectors report to the chief engineer, or to the principal assistant engineer. During the last year nine inspectors were detailed for the inspection of pavements on which the original guarantee is still in force. Seven inspectors were assigned to pavements upon which the original maintenance period had expired.

Contractors for paving cannot be held closely to the specifications of their contracts because of the lack of inspectors of the bureau of highways at the plants of the various paving companies.

The time required for completion depends upon the extent of contract. The contractor is under orders from the engineer of the bureau of highways as to details in the prosecution of the work. Days in which the contractor is prevented by reason of the weather or other unforeseen difficulties are not included in the computation of the number of consecutive working days specified in the contract. Contracts usually provide for damages to the extent of $10.00 per day.

Assessment work for the paving of a street which has never previously been paved is paid for by the abutting property owners, and is authorized by a resolution of the board of estimate and apportionment. The surveys and plans for such work are prepared by a city surveyor, who is not a regular city employee, but appointed by the borough president. The chief engineer of the bureau of highways, under the department of the borough president, compiles the assessment list from the plans and surveys of the city surveyor, together with reports made on such work by the regular inspectors of the bureau of highways. This assessment list is forwarded to the commissioner of public works, who in turn forwards it to his superior officer, the borough president, for approval. The borough president then transmits this list to the board of assessors, and tax bills are made in accordance therewith.

Repaving and repairing of streets and highways are entirely paid for by the City of New York at large, from the funds raised by the issue of corporate stock, special revenue bonds, or from annual budget accounts. The borough president is the sole authority for action in the matter of repaving and repairing of streets and highways. In this class of work the surveys and estimates preparatory to bids are made by engineers of the bureau of highways.

In accordance with various acts of the legislature, and resolutions of the common council, surface street railroad companies are liable for the cost of paving and repaving of the area contained within their rails and two feet outside of the outer rails of their tracks. Bills for such work are sent to the various street railway companies by the borough president upon reports made by the chief engineer of the bureau of highways.

There is special assessment work in connection with paving. Rebates are granted when the amount of the deposit exceeds the amount required for restoration of the cut.

Sheet asphalt covers a larger area in the highways of the Borough of Manhattan than any other kind of pavements, and is the most satisfactory general pavement. At present there is being given to the creosoted wood

block an extensive trial in the Borough of Manhattan on streets below Fourteenth Street carrying very heavy traffic. The following general recommendations are offered:

That the foundation of all streets should be concrete, to a depth of at least six inches.

That the period of maintenance should be reduced from five to one or two years.

That the circumstances pertinent to the granting of time allowance to contractors should be known personally, either by the chief engineer or the principal assistant engineer.

City surveyors should not be employed by bureau of highways; assistant engineers should be appointed instead.

Preliminary surveys and estimates should be more accurate and more comprehensive.

The specification should require an asphalt block of the specific gravity of not less than 2.50, the test for the same to be made upon a full-size block, and that abrasion tests also should be carried on by the bureau of highways.

Bids should be advertised for and contract let early in year.

Only competent inspectors should be employed in order to prevent faulty work and the use of faulty material.

Inspectors paid by the city should be stationed at the asphalt and the wood-preserving plants.

Inspectors' records should be made more comprehensive and should be compiled to serve as cost records of work.

Force of inspectors on maintenance should be doubled and borough divided into inspection districts to insure prompt repair and efficient inspection of paving and repaving. It is possible that the work of restoration could be more efficiently and promptly accomplished if maintenance contracts were let for each district to be awarded to a single company.

Police and street cleaning departments should assist bureau of highways by notifying it of defects in pavements and preventing bonfires.

Pipe galleries should be constructed.

Public service corporations should not be allowed to inconvenience the public in laying subsurface structures.

Corporation inspectors should not be paid by the public service corporations, but by the city, and should be a part of the regular force of the bureau of highways.

All openings in pavements should be through permits issued under one special official.

Map showing all existing subsurface structures should be made.

CHICAGO

By FREDERIC REX, Assistant City Statistician, Chicago, Ill.

For the past ten years all paving improvements in Chicago, have been in charge of a board of local improvements, consisting of four members and a superintendent of special assessments, who also acts as secretary of the board. It is the duty of this board to originate all acts for local improvement as well as hold public daily sessions for the transaction of business. Public hearings are given to property owners supposed to be benefited by any proposed paving improvement, notice of such hearing being sent them at least five days prior to the hearing. At the public hearing the board must show the necessity of the planned improvement, its nature and estimated cost. In case objection is made the board may in its own discretion "alter or modify the extent, nature, kind, character and estimated cost," provided such change does not increase the estimated cost of the improvement by twenty per cent, or it may entirely abandon the same. However, when a remonstrance petition is filed with the board by a majority of frontage owners on the line of the proposed improvement within thirty days after the public hearing thereon, all further proceedings thereon are stayed for one year. If no such petition is filed the board submits to the city council an ordinance ordering the improvement together with a recommendation signed by at least a majority of its members for its passage. Appended to the foregoing recommendation must be an estimate of the probable cost of the improvement, itemized so far as deemed necessary.

One-half of the frontage owners along any street may originate plans for its improvement by petitioning the board, whereupon the latter at a public hearing determines the nature of the same together with its cost and transmits to the city council an ordinance including the estimated cost with the usual recommendation for its passage. Upon the passage of an ordinance for a local improvement by the city council it is the duty of the secretary of the board of local improvements to file a petition in the county court, together with a copy of the ordinance as passed, of the estimated cost of the improvement as fixed by the council and of the recommendation of the board upon the proposed project. In addition there must be filed an assessment roll showing a true and impartial spreading of the assessment of the cost among the abutting property owners in proportion to benefits received, with an estimate of the percentage of the total cost to be charged to the municipality as "public benefits."

At least two weeks' notice must be given to all interested parties before confirmation of the assessment is moved in the county court, such notice stating the total cost of the improvement, the amount assessed as benefits to the public as well as the amount assessed against the property owners thus notified. The court has final jurisdiction and power to correct and revise the assessment levied and change the distribution of the total cost among the contiguous land owners for the purpose of obtaining a just and equitable assessment, its judgment acting as a lien upon the property assessed for a period of five years after the assessment has been paid. However, should

any owner believe that his property is assessed more than its proportionate share he may demand a trial by jury upon this issue.

The cost of street paving is borne, in the great majority of cases, by the adjacent property owner solely, by a special assessment of his property, in a few excepted instances an allowance being made for "public benefits," which is assessed against the municipality. In fixing the "public benefits" which the city must pay, consideration is given to the extent and character of the team traffic upon a street and to what degree the street will be subjected to through traffic which neither originates nor ends on such particular thoroughfare, the rate allowed in consequence varying from six per cent to twenty-five per cent of the total cost.

As an accommodation to property owners the cost of the improvement may be divided into five or ten annual instalments. Bonds payable out of such instalments, may be issued in anticipation bearing five per cent interest. These bonds are a lien upon the property benefited and do not constitute an obligation against the municipality. Street railway companies are required to pave such portion of the street which may be between tracks along their right of way and at all times keep the pavement in good condition.

The collection of the amounts due for street paving falls within the sphere of the city collector until March 10 of each year after which all delinquent assessments are turned over to the county collector, who has power to enforce payment. It has been noted that there is no adequate reason for the maintenance of this dual system of collection as it results in a useless duplication of accounts and merely serves to confuse. In case the amount collected for paving a street exceeds the final cost, the excess is refunded *pro rata.* The same procedure obtains for the enforcement of payment of unpaid assessments as in other proceedings to recover judgment for delinquent taxes.

In securing bids for the construction of a proposed improvement the board of local improvements is required to advertise for the same in some newspaper of general circulation, either for the work as a whole or in specified sections. The time for opening the bids received must not be more than fifteen nor less than ten days after such advertisement is published. All bids to be entitled to consideration must be accompanied by cash or a certified check of ten per cent of the aggregate cost of the improvement, payable to the order of the president of the board in his official capacity.

The board may reject any or all proposals when it believes such a course subserves the interests of the community. It is compelled to do so whenever it is of the opinion that collusion exists between the contractors either to limit the number of bidders or to increase the contract price, and that the lowest bid is made in consequence thereof. It can also reject the bid of any party who has been delinquent in the performance of any prior municipal contract as well as of all parties other than of the lowest responsible bidder.

Award of contracts must be made within twenty days after the time fixed for receiving bids. A failure to make an award within such time renders it necessary to readvertise for proposals, and all checks deposited by former bidders are returned. Should any bidder, upon receiving an

award of contract fail or refuse to enter into the performance of the same, the certified check or cash accompanying the bid is declared forfeited to the street maintenance fund of the city.

If a majority of the property owners are of the opinion that the cost of the proposed improvement is excessive, they may within ten days after the publication of the award of contract, elect to undertake the work upon agreement to perform it at ten per cent less than the price at which the contract had been awarded. It has been provided in the new city charter soon to be submitted to the voters for approval, that the board of local improvements may, upon authorization by the city council, lay a street pavement in case it can do so more cheaply than the price submitted by the lowest responsible bidder.

Contractors, at the time of entering into a contract, must give a personal or surety bond for double the amount of the total cost of the proposed improvement.

At the close of 1906 there were 1,544.77 miles of improved streets and alleys in Chicago, of which 34.89 per cent were paved with cedar block; 34.26 per cent with macadam; 20.96 with asphalt; 5.96 per cent with brick and 3.38 per cent with granite block. During the past year there were laid 52.42 miles of asphalt; 43.47 miles of macadam; 5.16 miles of brick and 3.91 miles of granite, making a total of 106.10 miles. Inasmuch as the local soil is either sand or clay no particular difficulty or special attention as to preparation is involved.

The cost of laying pavement is as follows:

	Per sq. yd.
Asphalt	$2.20
Brick	2.45
Concrete	2.50
Creosoted block	3.25
Granite block	3.75
Macadam	1.25
Novaculite	1.25

For comparative purposes these various prices would be of little, if any value, unless one take into consideration various items that go to increase the cost of an article, such as a long haul of material and the question of wages, the quality of work rendered supposedly being the same under the circumstances. A bitulithic pavement, three-quarters of a mile in length, has been laid by one of the city's park boards, its cost being slightly less than $3.00 per square yard. Cedar block is no longer laid, and when worn out is replaced by other material.

Asphalt, brick, creosoted and granite block pavements are laid on a foundation of Portland cement concrete of a uniform thickness of six inches; macadam on a foundation of nine inches of limestone and three and one-half inches of crushed granite; concrete on six inches of cinders, and novaculite on ten inches of limestone. The work of laying these pavements is subject to the rigid supervision of the board, its inspectors having authority to order

the dismissal of any employee of the contractor who refuses or neglects to carry out the provisions of the specifications, as well as order the removal of rejected material and the replacement of all work improperly done at the expense of the contractor. The time limit fixed for the completion of work varies with each contract, the measure of damages being at the rate of $25.00 per day for each and every day elapsing after the time specified for completion. Where the contractor is delayed by the city in any way the time of such delay is added to the time originally allotted. Before the acceptance of a paving by the city the contractor must guarantee to keep the same in continuous good condition and repair for a period of from five to ten years following the completion and acceptance of the improvement. Although subject to evasion on the part of contractors, it has been the policy of the city authorities to secure the enforcement of this provision wherever possible.

In deciding upon the satisfaction given by a pavement one must view the situation from a relative standpoint. A pavement which may give perfect satisfaction when laid in a street exposed to light or moderately heavy traffic may be entirely unsuited to the business section of a city, or when laid in the vicinity of docks, warehouses and factories. Granite pavement, chiefly laid in the business section of Chicago, has been generally acknowledged as alone meeting the requirements of its excessively heavy traffic. For streets with moderately heavy traffic creosoted block and asphalt have been found most adaptable. Asphalt has also been laid in the light business and more generally used residence streets, while brick and macadam have been placed in the outlying, unfrequented and suburban districts as most suitable to such localities.

In concluding, it may be stated that the present method of taxation for street improvements is antiquated and an imposition upon the taxpayer. Property owners are subjected to repeated special assessments for paving and repaving of streets whose pavements have been worn out not by themselves, but by the community. To illustrate, cases may be instanced where streets serving as busy arteries of traffic have been replaced at least once every five or six years, it being no uncommon occurrence for the same property owner to be assessed for a new paving of his street before he has paid the last instalment due on the old. The frequency of such repavement is evident when one considers that of $3,200,000 expended for street paving purposes in 1904, a total of $2,288,000, or seventy-one per cent was for replacing former pavement. In 1905 the sum of $2,150,000 was expended for repaving out of a total of $3,800,000, being fifty-seven per cent of the whole, while in 1906 out of a total of 106.10 miles of pavement laid, forty-four per cent was repavement. Such frequency of reassessment, occurring with well-defined regularity, savors of the nature of a tax and has left its impress upon city real estate values. To alleviate so exasperating a state of affairs the Chicago charter convention has embodied in its draft of a new charter a clause to the effect that "not more than fifty per cent of the cost of repaving any street or alley at any future time shall be imposed upon property by special assessment or special taxation."

One of the most effective causes of the early decay of newly-laid pave-

ment is the continued opening of the same by public service corporations in order to gain access to gas mains, cables and for the laying of service pipes. Inasmuch as a pavement whose arch has once been broken can never be put back into its former good condition, it should be incumbent upon such corporations to lay in every unpaved street all its necessary mains and laterals, upon receiving notice of the proposed improvement.

The street paving problem of Chicago may be summed up by quoting John W. Alvord, the well-known consulting engineer:

"The City of Chicago has already spent many millions of dollars wastefully upon its public streets. It has already spent enough money to be a well-paved city, but it has spent that money uneconomically and without careful study.

"There are accomplished, intelligent and educated engineers in the city hall who understand paving problems, but their assistance is not often sought. Their time is filled with innumerable details, and the tax payer has for years insisted upon his right to decide the kind and cost of paving of his street as a local and neighborhood question, and has resisted the attempts of any city administration to force upon him anything like a general policy with reference to the paving of the city as a whole. The board of local improvements should arrange a general policy of improvement, outline methods and classify the streets, designating the kind of improvement to go with each class, recommending such legislation as will enable adequate maintenance to accompany all construction, and see to it that some system is devised by which such maintenance shall be skilfully, thoughtfully and persistently carried out.

"In spite of all these sad leakages, Chicago is going to be a splendidly paved city. Our city comptroller says $4,000,000 of new pavements were ordered by the board of local improvements last year, and for pavements of the highest class. At this rate every street in the city (reasonably populated) will have a new pavement before 1912."

PHILADELPHIA

By ERNEST S. BRADFORD, University of Pennsylvania.

There are in Philadelphia (Jan. 1, 1907) 1,747 miles of streets and roads or which 1,277 miles are paved; the rest are dirt roads. Asphalt and granite blocks are the two principal kinds of paving, with about 380 miles each, while macadam and vitrified bricks come next, with 273 and 145 miles respectively. The following table gives the details for 1905 as well as for 1906:

	Cobble and Rubble.	Granite blocks.	Vitrified bricks.	Sheet Asphalt.	Block Asphalt.	Macadam.	Granolithic.	Slag blocks.	Total miles.
Total miles, Dec. 31, 1905.	61.40	378.60	145.71	360.64	19	273.34	12.77	9.82	1261.33
Total miles, Dec. 31, 1906.	60.57	379.40	147.95	372.04	19	276.06	12.77	9.82	1277.61
Per cent.....	4.74	29.70	11.58	29.12	1.49	21.60	1	.77	100

The average cost of new paving, from figures furnished by the bureau of highways, has been as follows:

	Per. sq. yards.			
	1903.	1904.	1905.	1906.
Granite block on concrete base	3.38	3.08	2.92	2.91
Sheet asphalt on concrete base } Trinidad Lake	2.18	2.18	....	....
Sheet asphalt on concrete base } Refined natural	...	...	1.92	1.65	1.56
Vitrified brick on concrete base	2.23	2.33	1.86	1.68

The city has been removing the old cobble and rubble pavements for a number of years, and has discontinued the use of granolithic pavement, asphalt blocks and slag blocks, as they have proved unsatisfactory. Granolithic surfacing is hard to keep in repair when a break occurs unless immediate attention is given, the entire pavement disintegrates rapidly. Asphalt blocks break at the base while the surface is apparently intact, and the blocks soon crumble, necessitating the substitution of new material. Slag blocks, which look well, are expensive and the edges soon chip, and the whole block becomes slippery.

Granite blocks, sheet asphalt and vitrified bricks, however, have stood the test—the first named for heavy traffic and steep grades, brick for medium traffic and grades, while asphalt furnishes a smooth, durable pavement for heavy and light vehicles, but is slippery on either medium or steep inclines.

The process of paving is the usual one of excavating to a depth of fourteen inches for granite blocks, eleven for brick, and nine for sheet asphalt; rolling the dirt with a ten-ton steam roller; laying a six-inch mixture of cement (one part), gravel (three parts) and hard stone or slag (six parts); then two inches of sand for granite blocks, or one inch for bricks, upon which the pavement proper is placed and tamped. The joints between granite blocks are filled with hot pitch and fine gravel; those between the vitrified bricks with cement grouting.

The laying of pavements is inspected by city officials, who report all violations of contract, and may order the paving stopped. These men are appointed under civil service rules, but many men who know paving thoroughly, often do not pass good technical examinations. Contractors are held to the specifications with reasonable strictness. The contractor specifies in his contract the time limit within which he will complete the work, and a penalty of $25 a day is provided for each day after the specified limit. Bids for new paving and for repairs are advertised in at least three daily city newspapers for ten days prior to time of opening bids, and contracts are let to the lowest responsible bidder. The director of public works may reject any bid which is made by an irresponsible person, and let the contract to the next higher bidder. The contractor places a bond of $500 with his bid, and in case he receives the contract, furnishes security in one-half the amount of the contract. The cost of new paving is borne entirely by the adjacent property owners, except intersections of streets and those in front of city property or unassessable property, such as churches, cemeteries, etc. The assessment bills against each title of property are turned over to the paving contractor, who collects directly from the owner, thus saving the city the cost of collection.

Repairs, however, are made at the expense of the city. Streets occupied by street railway companies must be kept in repair or repaved from curb to curb by them. The contractor must guarantee the pavement for five years after completion, and keep it in repair during that time at his own expense.

ST. LOUIS

By JAMES C. TRAVILLA, Superintendent Street Department, St. Louis, Mo.

Municipal work and improvements in St. Louis are in charge of the board of public improvements, consisting of six members. The president is elected by the people for a term of four years and has general supervision over all the departments. The other members, appointed by the mayor for a term of four years, are the heads of the several administrative departments, to wit: street, sewer, water, harbor and wharf and park.

Ordinances authorizing municipal paving must originate with the board, be passed by the municipal assembly, composed of two houses known as the council and house of delegates, and be approved by the mayor.

The notice of the letting of contracts is published three times in the newspapers doing city printing, the last publication to be at least ten days before the day appointed for the opening of the bids. Such notice states the general nature of the work, the place where plans, specifications and forms of contracts may be seen, the amount of the certified check on some bank or trust company, payable to the order of the city treasurer for the amount of the deposit required, as hereinafter mentioned, the time and place where the bids will be received and the hour and place for opening the bids.

Each bidder makes his bid upon blank forms furnished by the street department. The bid, together with a certified check, is placed in a sealed envelope, addressed to the president of the board of public improvements. If the estimated cost be $3,000 or less, ten per cent of the total cost of the work as estimated is required as a deposit; if the estimated cost be more than $3,000, the deposit must be ten per cent on $3,000 and two and one-half per cent on the excess above that amount. No deposit less than $50 is permitted. The certified checks are returned as soon as the contract is awarded.

The board is authorized to reject any bid for the following reasons: Bid blank not properly filled up so as to make a bid complete; bid blank having alteration or erasure upon it; bid blank not properly signed; failure to enclose certified check with bid; bidder not a responsible party: "No person, firm or corporation shall be deemed a responsible bidder who has failed or refused to fully carry out any contract let to him or them for doing any city work." The board also reserves the right to reject all bids whenever, in its judgment, the interests of the city may require it.

For the faithful performance of all contracts made by the board a bond is required signed by at least two sufficient and approved securities in amounts as follows: When the estimated amount of the contract is $5,000 or less, the bond shall be for the full amount of the contract, and when the estimated amount of contract is over $5,000, the bond shall be for $5,000 and twenty-five per cent on the amount of the estimate in excess of $5,000.

KIND AND AMOUNT OF PAVING MATERIAL.

MATERIAL.	Miles.	Square Yards.	Avg. Cost per Sq. Yd. 1906.	Remarks.
Vitrified brick	96.47	2,164,230	$1.70	Six-inch base Portland cement concrete.
Granite blocks	63.48	1,445,980	2.60	Six-inch base Portland cement concrete.
Asphalt	45.42	1,084,190	1.60	Five-inch base Portland cement concrete.
"Bitulithic"	24.40	637,140	2.15	Five-inch base Portland cement concrete. One-inch macadam tamped into concrete.
Wood blocks	2.50	49,800	3.25	Six inch base Portland cement concrete.
Total	232.27	5,381,340	.....	Concrete mixed in the proportion of 1–4–7.

Curbing.—Granite curb is used. The stone must be not less than sixteen inches deep, six inches thick and four feet long.

The top and face is required to have a rough, pean-hammer finish, the face dressed to the full depth of the stone and the bottom roughly squared; the backs of the stones are dressed parallel to the face to a depth of four inches below the top. The curb is set in concrete six inches deep and backed with concrete six inches wide to a line six inches below the top of curb. The cost of curbing, furnished and set in concrete, is ninety cents per lineal foot.

Vitrified Brick.—The vitrified bricks shall not be less than eight inches nor more than ten inches long, not less than two and one-half inches nor more than three and one-half inches wide, not less than four inches nor more than four and one-half inches deep. They shall be free from lime or other impurities, uniform in size and quality, thoroughly burned and annealed and free from internal flaws, cracks and laminations.

They shall show a modulus of rupture on cross-breaking of not less than 2,000 pounds per square inch.

They shall not lose more than twenty-five per cent of the original weight in the rattler.

The "rattler" is twenty-eight inches in diameter and shall make thirty revolutions per minute. The number of revolutions for a test shall be eighteen hundred.

They shall not absorb more than two per cent of their own weight of water after being immersed in water forty-eight hours. An absorption of not exceeding four per cent may be allowed in case the brick will show a loss of weight by abrasion of not over twenty per cent of the original weight of the brick.

The absorption test shall be made on bricks that have passed through the "rattler."

Granite Blocks.—The granite blocks shall not be less than nine inches nor more than twelve inches long, not less than three and one-half nor more than four and one-half inches wide, not less than five nor more than six inches deep, and dressed true to the square, closely approximating a rectangle in every section.

All blocks shall have smooth tops and smooth sides and square ends to at least two-thirds of their depth. No bunches on top exceeding one-fourth inch shall be permitted

The depth of each block at both ends and the middle must be as nearly uniform as possible and in no case show a difference of more than one-half inch.

Blocks shall be laid on a two-inch bed of sand. Joints of the blocks shall not exceed five-eighths of an inch and longitudinal joints broken so as to leave a lap of at least three inches. Joints must be filled with sand.

Asphalt.—The asphalt pavement consists of a binder course one and one-half inches in thickness and a wearing surface one and one-half inches in thickness. The binder course is a bituminous concrete, composed of broken stone or gravel not exceeding one and one-fourth inches in their largest dimensions and asphaltic cement made from the best refined asphalt. For the binder course, fifteen gallons of asphaltic cement is used to one cubic yard of stone. Upon the binder course is laid the wearing surface which shall consist of

Asphaltic cement	9	to	17	per cent
Sand	86	to	68	per cent
Carbonate of lime (lime dust).....	5	to	15	per cent
	100		100	per cent

The asphaltic cement must be varied according to quality and character of sand. The paving mixture is delivered on the ground at a temperature

of about two hundred and fifty degrees Farhenheit. After the surface has been rolled, a small amount of Portland cement is swept over it.

Bitulithic.—This class of pavement is composed of carefully selected, sound, hard, crushed stone, varying in size from one and one-half inches to one-tenth of an inch in diameter, proportioned to give the greatest density of mineral aggregate and the greatest inherent stability of the mineral aggregate. The stone is mixed with a sufficient amount of Warren's bituminous cement, so as to thoroughly coat every particle and to fill all the voids in the mixture. The wearing surface to be two inches thick after compression.

Wood Block.—The treated wood blocks to be of southern long-leaf yellow pine, not less than ninety per cent of heart.

Their depth (parallel to the fibre) shall be three and one-half inches, their length shall be not less than six nor more than ten inches, and their width shall be not less than three nor more than four inches, but all the blocks used in any contract shall be of the same width. Their depth and width shall not vary more than one-eighth inch from the dimensions specified for any contract.

Blocks shall be treated with an antiseptic and water-proof mixture seventy-five per cent of which shall be dead oil of coal tar, commonly known as creosote oil and twenty-five per cent resin.

All parts of each block shall be thoroughly treated and not less than twenty pounds of the mixture per cubic foot shall be injected.

The blocks shall not show a gain in weight greater than three per cent after being immersed in water twenty-four hours.

The blocks are laid at an angle with the curb. One-half inch expansion joint shall be placed along the curb and at intervals of about one hundred feet. The joints are filled with a paving mixture of tar and sand.

The above-named materials have many of the requirements for the ideal pavement, which should be cheap, durable, easily cleaned, present little resistance to traffic, non-slippery, noiseless, sanitary and easily maintained. However, there are objectionable features associated with the use of each class of material, viz: vitrified brick is noisy and chips under traffic; granite blocks are noisy, wear slippery and will cobble; asphalt and "bitulithic" depend upon the manipulation of the cementing material and will not stand up under extremely heavy traffic; wood blocks are more or less slippery and costly.

In selecting the material, the character of the traffic, street grades and the values of property should be carefully considered. Granite blocks should be limited to the railroad and manufacturing districts, where there is much heavy hauling. Vitrified brick, asphalt, "bitulithic" and wood blocks are best suited for streets in the residential districts and for certain business streets. Wood blocks for the central business districts, where are located office buildings, department stores, etc.

Before proceeding with municipal paving, it is very necessary to have installed all underground work. The continual tearing up of the streets for house service connections, conduits, etc., is a source of trouble and annoyance and destroys the life of the pavement; however, with civic improvements continually taking place, such as placing overhead wires underground, etc.. pavements will continually be disturbed, and such tearing up must be looked upon as a necessity in a progressive city.

The contractor is required to maintain in good order the grade and surface of the pavement and material used in connection therewith for a term of five years; shall make all necessary repairs occasioned by the construction of sewers, conduits, etc., at a stipulated price; to complete the work

within a specified time—the time of beginning, rate of progress and time of completion being essential. Liquidated damages for failure to complete the work within the time specified are fixed at five dollars per day for the first ten days and ten dollars per day for each and every day thereafter.

Contractors are paid by special tax bills, which are a first lien upon property assessed. Bills so issued are divided into six equal parts: the first instalment becomes due and is payable thirty days after due notice thereof without interest; the remaining instalments become due and are payable at intervals of one year thereafter. Bills bear interest at the rate of six per cent, and after maturity at eight per cent. Tax bills after being registered by the city are turned over to the contractor for collection.

Special taxes for municipal paving are levied and assessed as follows: The total cost of all the work of grading and paving, including intersections, is ascertained, and one-fourth thereof assessed upon all the property fronting or adjoining the improvement. The remaining three-fourths of the cost so ascertained is levied and assessed in a district, in the proportion that the area of each lot or parcel of ground lying within the district bears to the total area of the district exclusive of streets and alleys. The district is fixed by drawing a line midway between the street to be improved and the next parallel or converging street on each side of the improvement. The only portion of the cost borne by the city is upon city real estate and property exempt from special taxes. Street railway companies pay for paving the space between tracks and rails and for a distance of one foot outside of the rails.

The rigidity of the law for fixing assessing districts causes much trouble and litigation, because of the irregular platting of the city, and is not recommended as being practicable. It should be amended so as to give the board certain powers in fixing district lines or the assessment should be limited to property fronting or adjoining the improvement, and the city should pay for all street and alley intersections.

The cost of municipal paving should be paid in full at the time of the completion of the work by the city, and the city should be reimbursed by the collection of the tax bills. The money necessary to pay the contractor should be raised by the issuance of improvement bonds.

BOSTON

By Charles Herbert Swan, Esq., Boston, Mass.

Paving operations in the City of Boston are in charge of the street department. The legal requirements for the letting of paving contracts are apparently comprised in the requirements for all city contracts as set forth in the acts of the legislature of 1890, Chapter 418. Section four of that chapter says: "Every officer or board in charge of a department in said city, ... when about to do any work or to make any purchase, the estimated cost of which amounts to or exceeds two thousand dollars, shall, unless the mayor give a written authority to do otherwise, invite proposals there-

for by advertisements in not more than four daily newspapers published in said city, ... and reserving in such invitations the right to the officer or board to reject any or all proposals."

Section five says that every proposal for doing such work, etc., "shall be accompanied by a suitable bond, certified check or certificate of deposit, for the faithful performance of such proposal." Further, all such proposals shall be kept "and shall be open to public inspection after said proposals have been accepted or rejected." Section six provides that all contracts involving two thousand dollars or more must be in writing, approved by the mayor and "shall be accompanied by a suitable bond or deposit of money or other security for the faithful performance of contracts."

In the case of Warren *vs.* Street Commissioners (181 Mass. Reports, page 6 to page 9), "it appeared that it is the custom of the superintendent to make, at the beginning of the year, contracts as required by law for supplying the city with paving blocks, edgestones, gravel, brick, flagging and lumber, and to use the same whenever required for the various pieces of street construction, charging the cost of the amount used as a part of the construction at the prices paid in such contracts; and it further appeared to be his custom to make leases of ledge lots for quarrying stone," etc., the city crushing the stone and using it for street construction, "charging the same as part of the cost of such construction at prices determined by the superintendent to be the actual cost thereof."

This case commented rather severely on certain practices of the department in letting contracts, the court saying "The contrast between what the statutes required and what was done is striking." The court also remarked that the great work to which that case refers was carried out "with a plain, direct and persistent disregard of the requirements of the law," etc. It is only fair to say, however, that it did not appear that there was any serious increase in the cost as a matter of fact.

According to a report of the street department of the City of Boston the public streets within the municipal limits showed the following kinds of pavement in mileage and area on February 1, 1905:

Kinds.	Mileage.	Sq. Yards. About.
Asphalt	20.71	335,000
Granite block	95.62	2,108,000
Wooden block	0.91	23,000
Planks on bridges	2.10	43,000
Brick	0.38	3,600
Cobble	0.30	2,300
Bitulithic	3.16	60,000
Macadam	334.00	6,077,000
Gravel	38.54	605,000
Ungraded	6.48	253,000
Total	502.20	9,509,900

The cost of paving is approximately as follows:

	Per sq. yd.
Asphalt	$3.75
Granite block	4.75
Wood block	4.25
Bitulithic	3.50
Macadam	1.00

The soil of Boston is generally gravelly, but the kinds of paving required in different sections of the city of course differ greatly, as illustrated by the foregoing table. The city is divided into inspection districts corresponding approximately to the old towns of which the present municipal territory is composed. The inspectors are expected to report daily to headquarters. It is impossible to say how closely the contractors are held to specifications, but the statute specifically forbids the changing of contracts without the approval of the mayor and the department head. Some excellent paving has been laid in Boston and there is also some that is very inferior.

The betterment provisions of the revised laws authorize special betterment assessments on adjoining lands for a portion of the cost of "laying out, relocating, altering, widening, grading or discontinuing a way," and special statutes authorize such assessments in Boston for similar purposes connected with street construction. In so far as paving is done in course of street construction the cost in part is paid by these assessments, but for mere renovating or repairing it falls to the current expenses of the city. These special assessments are not charged to the abutting property owners alone, but are charged on the real estate within a certain distance of the constructed street as well, and are enforced by a sale of the premises under the procedure for selling for the annual taxes. They may, however, at the request of the owner, be apportioned over a period of ten years by instalments with interest. These assessments do not cover the whole cost in any case. The balance is part of the general expense.

The street railway company is required to restore the pavement in laying its tracks, and generally a company opening the street is supposed to do so, but the quality of the work often seems deficient. The most satisfactory paving for heavy traffic in Boston seems to be granite blocks. Asphalt is frequently rendered slippery in this climate, but is used in some level stretches in parts of the city. In the year 1904 the total cost of maintenance of the paving division was $1,073,445.42.

BALTIMORE

By HENRY JONES FORD, Editor *The News,* Baltimore, Md.

In the past, street paving in Baltimore was done under instructions from the city council, which would from time to time pass paving ordinances by combination among councilmen interested in such measures. Reports were current that such ordinances reflected agreements among paving companies who had pooled their influence in promoting favorable action. It was the

practice to designate the kind of paving material to be used, and it was charged that the effect was to prevent competition and open the way to high prices. The city engineer in a public statement declared that the city had to pay from $2.25 to $3.50 a square yard for pavement that was laid in Washington at from $1.57 to $1.77 a square yard.

An attempt was made to introduce a better system by means of an ordinance providing that different sorts of pavement should be used in different localities—Belgian blocks for streets where travel was heavy, wood blocks around hospitals and public buildings where relief from street noise was specially desirable, sheet asphalt or bitulithic for residence localities. This ordinance, first introduced December 18, 1905, was sketched by the city engineer and draughted by the city solicitor. There was a long and heated controversy over it in the city council, incidentally stopping all paving operations. The struggle was complicated by the fact that the asphalt companies opposed bitulithic pavement, and when defeated in the city council appealed to the courts. Mayor Timanus took an active part in the fight against what was known as "the paving combine," and it was eventually defeated both in the courts and in the city council.

The ordinance now in effect, embodying the city engineer's recommendations, provides that certain streets shall be paved with wood blocks, others with Belgian blocks, others with asphalt blocks, while on others either sheet asphalt, asphalt blocks, bitulithic or vitrified bricks may be laid as may be found expedient. It is expected that the latitude of choice permitted will enable the city authorities to get the work done at a lower cost than heretofore.

The cost of any pavement depends in a measure upon the distance which materials have to be hauled and any conclusions reached by comparisons without taking this element into consideration are likely to be erroneous.

Range of prices for work now in course of construction.

	Per square yard.
Wood block	$2.45 to $2.50
Bitulithic	2.15 " 2.25
Sheet asphalt	1.92 " 2.05
Asphalt blocks	2.13 " 2.25
Vitrified brick	2.00
Belgian block	2.20
Belgian block (concrete base)	2.85
Belgian block (concrete base and asphalt filling in joints)	3.20

An important factor in the situation has been the control of the board of estimates over the appropriations. While the city council may pass paving ordinances it can not make any appropriation unless first recommended by the board of estimates, consisting of the mayor and his chief administrative associates. This control eventually turned the scale against "the paving combine." To escape similar contention in the future, the city author-

ities procured from the state legislature in 1906, the passage of an act creating a paving commission, and authorizing a loan of $5,000,000 to defray the cost of the work of that commission. The members are to be nominated by the mayor and confirmed by the second branch of the city council as in the case of other appointed city officials. They are five in number, only the chairman receiving compensation, which is fixed at $2,500 a year. Some engineer will be selected for that post. The commission has discretionary authority to adopt such "plans of street improvement as it may deem best calculated to promote the object of this act." It may select any kind of paving material it sees fit, but must award contracts to the lowest responsible bidder.

Special need for this public agency was due to the fact that Baltimore is introducing a sewerage system involving the construction of 1,100 miles of sewers. In connection with the incidental tearing up of streets, it is proposed to repave them to the best advantage. About the only restriction on the authority of the commission is that it shall not pave any street until the sewerage arrangements in it shall have been completed.

The five million loan has yet to be submitted to the people, and the commission has not yet been appointed. Baltimore has many rough cobblestone pavements, relic of a political system uprooted by the adoption of the new charter. When the improvements now pending are completed it is claimed that Baltimore will be the best paved and best sewered city in the country.

CLEVELAND

By A. R. CALLOW, Secretary of the Board of Public Service, Cleveland, Ohio.

The laws of the State of Ohio require municipalities, before making contracts, to advertise for not less than two nor more than four consecutive weeks in a newspaper of general circulation within the city. In Cleveland, each bid must be accompanied by a certified check, amounting to approximately ten per cent of the estimated contract price, on a solvent bank in the City of Cleveland. It has been customary to insist that the check be drawn upon and certified by a local bank. The reason for this is that the Cleveland officials are familiar with the responsibility of local banks. Checks are returned as soon as contracts are approved.

Bids are opened by the clerk of the board of public service, which board has charge of paving operations together with all public improvements. These bids are made upon estimated quantities compiled by the civil engineer and upon plans and specifications kept on file in his office.

Unit prices per square foot of pavement laid, per cubic foot of excavation, per lineal foot of curbing set, etc., are asked for. The law gives the board of public service the right to determine the lowest and best bidder. This power, so far as paving contracts are concerned, is very rarely exercised to accept a high bid for the reason that specifications for paving streets provide in very great detail the requirements as to quality of brick, cement, curbing material, etc. The only discretion, therefore, which the board could

really use, would be in a case where the sample bricks or other sample materials did not fulfil conditions prescribed.

The lowest bid is determined by multiplying unit prices by the estimated quantities as compiled by the engineer. Under the law, alterations or modifications of a contract may be made where it becomes necessary in the opinion of the board of public service to make such changes. These modifications can be made only when a resolution has been adopted by the board of public service declaring the necessity for the same, and an agreement has been made in writing with the contractor providing a price for the additional work. A bond of fifty per cent of the total amount of the contract is required of the contractor to insure the proper performance of the work.

Cleveland has 182 miles of brick pavement, ninety-two miles of stone pavement, twenty-three miles of asphalt pavement, one mile of Belgian block, one-half mile of bitulithic, one and one-half miles of macadam; this makes 300 miles of paved streets out of a total of 651.4 miles of streets in the city. Contracts have been let or legislation is pending which will add approximately seventy-five miles of paved streets before the end of 1908. Cleveland uses five-inch brick without a concrete foundation. A majority of the streets are sand, and the brick is laid without other foundation and filled with Portland cement, except in the gutters next to the curb, where a pitch filler is used to allow for expansion and contraction. On clay streets a cushion of sand eight inches thick is filled over the clay and the brick laid on the sand. The prices for the various kinds of pavement at recent lettings have been about as follows: Brick 15½ cents a square foot, stone $3.15 a square yard, asphalt $2.25 a square yard, bitulithic $2.10 a square yard.

The small amount of Belgian block pavement was laid by the bridge department employees during the winter months, and the cost per unit is of no value for comparative purposes. Cedar block is not used. Stone is used on business thoroughfares where traffic is heaviest. Six-inch concrete foundations are specified for both brick and stone pavements where the traffic is heavy enough to warrant it.

City inspectors watch every stage of the pavement building from the grading of the street to the removal of the barriers to permit the renewal of traffic. Contractors are required to follow closely the specifications, and the results of the rigid inspection are apparent in the quality of the work secured.

Limits of time within which contracts must be completed are prescribed, but vary according to the size of the job and other conditions. The city reserves the right to cause the work to be completed and the cost charged to the contractor and his bondsmen, if in its judgment, the paving is not progressing satisfactorily.

The largest portion of the cost of paving streets is borne by the abutting owners who pay by special assessment, per foot frontage, all the cost except that of paving the street intersections and one-fiftieth of the total cost of the improvement which are paid out of general funds of the city. Equitable exemptions are made for corner lots. The main frontage is taxed for the full number of feet and the side frontage for about one-half. The city pays one-half of the cost of repaving streets.

Where there are street railway tracks the company pays the cost of paving and keeping in repair the space between the outer rails including the "devil's strip" and eighteen inches outside each outer rail.

Telegraph, telephone and electric-light companies deposit money from which the cost of repaving over openings made necessary by installation or repair of conduits is taken and used to pay for materials and wages of city workmen who make the repairs.

Special assessments for street improvements are collected in ten semi-annual instalments except that abatements of part or all of the tax of the previous year are made in case the actual cost of the work is lower than the estimate. If the cost is higher an additional assessment is made, but this *very* rarely happens.

The city auditor certifies special assessments to the county auditor on or before the second Monday in September of each year. The county auditor then places them on the tax list and the county treasurer makes the collection with the general taxes and deposits them in due time with the city treasurer to the credit of each particular paving fund. Bonds are sold by the city in anticipation of the collection of taxes to pay the cost of making improvements. Paving is started after the first semi-annual payment has been collected by the treasurer. All subsequent payments by property owners are applied to the payment of the bonds, interest, etc.

Brick pavement has been found most economical for residence streets in Cleveland. Its life is from twenty to thirty years. Medina block stone is preferred for streets where traffic is heavy or where there are steep grades. Properly laid it will last fifty years of hard wear. Asphalt has not been satisfactory. Its life is the length of the guarantee which in Cleveland is ten years.

Cleveland is handicapped very much in carrying on street improvements by the restrictions provided by the Ohio state laws. Limits on bond issues for the city's portion and other provisions which should be left to the judgment of the city council as they are purely local in their application, hamper the successful completion of much needed improvements.

BUFFALO

By C. M. Morse, Deputy Engineer Commissioner, Buffalo, N. Y.

The charter of the City of Buffalo provides that all contracts for municipal paving shall be advertised for at least two weeks in the local papers. Bids are then received on the days specified. These bids are reported to common council—the commissioner of public works certifying to the one which is lowest. A certified check or bond must be filed with each bid. The successful bidder gives bond to fifty per cent of the amount of the contract as well as a maintenance bond covering a period of ten years.

Pavements in the city, excluding park system, June 30, 1906.

	Miles.
Asphalt on concrete	207.611
Asphalt on stone	20.019
Asphalt on macadam	.646
Stone on sand	80.765
Block stone	13.406
Brick	14.485
Macadam	12.291
Total	351.223

The cost of paving varies because it depends very largely on local conditions. For the year 1906 contracts were let at the following rates:

	Per sq. yd.
Trinidad (macadam base)	$2.56
Bermudez (old stone base)	1.297
Medina stone (concrete base)	3.43
Macadam	1.83

These prices are in each instance taken as a general average for the year 1906.

CINCINNATI

By MAX B. MAY, ESQ., Cincinnati, Ohio.

When it has been determined by the board of public service to proceed with a street improvement, under the law the board is required to advertise thirty days for bids. It has been considered sufficient if the advertisement appears twice during that period in newspapers of general circulation. The advertisement usually reads that sealed bids will be received by the board of public service at its office at noon on a given day for furnishing the necessary labor and materials for the improvement of a given street, setting out the length and character of the improvement according to the plans and specifications already on file. Each bid must contain the full name of every person or company interested in the same, and be accompanied by a satisfactory bond amounting to fifteen per cent of the cost, or a certified check on some solvent bank that if the bid is accepted, a contract will be entered into and its performance properly secured. Bidders are required to use printed forms furnished on application. The right is reserved by the board to reject any or all bids. After a bid has been accepted a contract is entered into between the City of Cincinnati and the contractor in which the latter obligates himself to complete the work within a given time according to annexed specification, and also agrees to keep the work in repair usually for a period of five years after completion. This contract is accompanied by a bond, signed by two sureties for twenty-five per cent of the amount of the contract,

for faithful performance in accordance with the plans and specifications, and ten per cent of the cost is reserved until final completion. This method of letting contracts has proven very satisfactory.

The report for the year 1906 is not complete, but up to and including December 31, 1905, there have been constructed in the city of Cincinnati:

Graveled roads	5.5	miles
Macadamized roads	35.0	"
Limestone avenues, streets and alleys	7.85	"
Asphalt avenues, streets and alleys	37.15	"
Brick avenues, streets and alleys	62.14	"
Granite avenues, streets and alleys	51.16	"
Bouldered avenues, streets and alleys	63.53	"
Macadamized avenues, streets and alleys	191.53	"
Bitulithic avenues and streets	1.84	"
Total	455.70	

The soil in the lower part of the city is gravel, an excellent foundation. The character of the soil of the remaining portion of the city is generally clay; the foundation needing underdrainage. The foundation required as to depth and kind, etc., varies with the kind of pavement.

Inspectors are appointed upon each piece of work, whose duty it is to see that the specifications are strictly complied with. Contractors are held closely to specifications. The time limit for completion varies according to the magnitude of the work. No liquidated damages are allowed. The only penalty inflicted is the salary of the inspectors if the contract time is overrun. The standard of the work is excellent.

The cost of paving is defrayed by adjacent property owners; by the municipality; by public service corporations, and by special assessments. If a street has never been improved, then the city pays two per cent of the entire cost plus the cost of intersections; the remainder is assessed against the adjacent property. If the street has once been improved, then the city pays the cost of intersections and fifty per cent of the remainder; the other fifty per cent is assessed against the adjacent property owners. Public service corporations are not assessed unless they be abutting property owners. Special assessments are entirely within the jurisdiction of the city council. No rebates are ever given.

After a street has been improved the city council passes what is known as an assessing ordinance fixing the amount due in accordance with the original proposition to improve, whether the assessment be by benefits or front foot or otherwise. This ordinance is then certified to the city auditor who places opposite the name of each property holder the amount due for said assessment against his property. The auditor then sends out postal notices to each owner, giving him the option to pay all in cash or to pay by instalments either in five years or in ten years as the case may be, the deferred

payments bearing four per cent interest and being a lien on the property. If, at the end of any period, the owner does not pay the assessment, the city auditor certifies the same to the county auditor who places it upon the tax duplicate and the owner must pay the said assessment when he pays his taxes.

The kind of pavement to be used depends a great deal upon the locality and the amount of traffic and the grade. Where the traffic is very excessive and the grade is light, a granite pavement is most satisfactory; where the grade is steep, a boulder pavement is best; where the traffic is not excessive and there are no car tracks and the grade is not too steep, an asphalt or a brick pavement is to be preferred; in the suburban districts where the traffic is light, on almost any kind of a grade a properly constructed macadam street gives the best results.

The cost of paving varies in accordance with specifications. It may be summarized as follows:

Granite or Belgian Blocks.—Six-inch hydraulic, concrete cement base, 1-2-5, two-inch sand cushion, granite block not less than six inches deep, tar filling, $4.00 per square yard.

Asphalt.—Six inches Portland cement concrete base, mixed, 1-2-5, one-inch asphalt binder, two-inch asphalt top coat, $2.35 per square yard.

Vitrified Brick Pavements.—Six-inch hydraulic cement concrete base, 1-2-5, two-inch sand cushion, vitrified brick four inches deep, tar filling, $2.00 per square yard.

Wood Block Pavements.—Six-inch Portland concrete base, 1-2-5, one-half Portland cement cushion, 1-2-3½ inch wood block, treatment with preparation seventy-five per cent creosote oil and twenty-five per cent resin, twenty pounds to one cubic foot lumber, $3.75 per square yard.

Bitulithic Pavements have been discontinued in Cincinnati. Heretofore it cost $2.50 per square yard.

Macadam.—Four-inch crushed boulder and ten-inch crushed stone, $1.25 per square yard.

Boulder Pavements.—Six-inch broken stone, $1.60 per square yard.

The above estimates are all exclusive of the cost of grading.

DETROIT

By Delos F. Wilcox, Ph.D., Secretary Municipal League, Detroit, Mich.

In Detroit all paving work is done under the supervision of the department of public works at whose head is a single commissioner appointed by the mayor for a term of four years. The commissioner may be removed on charges by a two-thirds vote of the common council.

It rests with the council to determine what streets shall be paved and the character of the material to be used. It rests with the commissioner of public works to prepare plans and specifications for the work, subject to the council's approval. The work may be done by contract, or by the

department of public works directly if the council so orders. In case the contract system is adopted, as is the usual practice, the commissioner of public works is required to advertise for bids, but there is no specific length of time prescribed during which the advertisements must run.

Recently an advertisement was dated March 13th and required that all proposals should be in the office of the department by 10 o'clock a. m. on March 19th. The advertisement covered eight paving jobs aggregating more than $100,000 in estimated cost. In the advertisement the time is set when each job must be completed and the detailed estimates on excavation, cubic yards of concrete, square yards of paving, lineal feet of curbstone, etc., are stated. Bidders are required to state their price per unit for each item of the work. Bids are not received unless they are for the entire work on any street or section of street, and the lowest bid as determined by aggregating the details based upon the city's estimates, is accepted, subject to conditions to be mentioned later.

Each bidder is required to deposit with his bid a certified check for approximately ten per cent of the amount of the contract. This check is forfeited in case the bidder refuses to enter into the contract within five days after the acceptance of his tender by the department. The commissioner has authority to reject all bids. Any contract recommended by the commissioner must go to the common council for approval. It is usually referred to the committee on streets and reported on at the next session. The successful bidder is required to furnish a surety company bond in the sum of thirty-five per cent for sheet asphalt and twenty per cent for cedar and brick, of the contract price for the work. On jobs which are to be paid for by special assessments the contractor receives his pay in bonds, or the proceeds of bonds if the sinking fund commission is in a position to purchase them. No bids are accepted from any person who is in arrears to the city upon debt or contract or who is in default as a surety or otherwise under any obligation to the city. Printed specifications in detail are furnished the would-be bidders on application. In the case of sheet asphalt pavements the contractor is required to furnish a ten-year guarantee of the work. In the case of brick pavements the brick are furnished by the city.

The kind of pavement laid is affected somewhat by the peculiarities of the paving law of Detroit. Original pavements are paid for by abutting property owners, except the cost of paving street intersections and paving between the street railway tracks in certain cases where this work is done at the expense of the company. All repairs and repaving are paid for out of the general road fund of the city. This fund is raised by general taxation with the same rate of assessment in all parts of the city. The common council may order streets paved, but it may not order more than $300,000 worth of new paving in any one year "except upon the petition of the holders of the larger portion of the real estate directly abutting upon the portions of the street or alley proposed to be paved." The result of this system is that heretofore practically all first pavements in residence districts have been of the cheapest available material, that is, cedar blocks.

The total amount of the various kinds of paving in the city on January 1, 1907, was as follows:

Cedar blocks	215.53	miles
Brick	58.80	"
Sheet asphalt	48.42	"
Block asphalt	2.83	"
Granite asphalt	2.20	"
Medina asphalt	1.41	"
Cobblestone	1.11	"
Silica barytic	.20	"
Macadam	.91	"
Bituminous macadam	.28	"
Kreodone block	.16	"
Total	331.85	"

The site upon which Detroit is built is almost level. The soil is for the most part of heavy clay. Drainage conditions are, however, very good considering the nature of the soil and the site, as there is a gradual but very slight rise from the bank of the Detroit River to the northern side of the city. The nature of the soil is such that a concrete foundation is considered necessary for practically all pavements. Many of the old cedar pavements were laid on planks or sand, but these are gradually being replaced with concrete. The depth of concrete required is six inches.

Every paving job is done under the immediate inspection of a representative of the commissioner of public works. A few years ago the system of inspection was very loose, and contractors were seldom, if ever, held to strict conformity with the specifications. As a result, however, of the activities of the municipal league and the dismissal of one commissioner of public works and one commissioner of parks and boulevards by the council, it is believed that the standard of work now required of paving contractors in Detroit is exceptionally high. Provision is made for damages in case the contracts are not complete within a specified time. In this case, however, the penalty is not always enforced as there seems to be a chronic condition of hold-ups for material or labor. Sometimes it is impossible to get cars for shipping in the materials required. The city is not equipped as it should be with a number of large storing yards where an adequate supply of materials could be kept against emergencies of this kind. As stated above, the cost of original pavements is paid by abutting property. The assessments are levied in proportion to frontage. Provision is made, however, that in the case of a parcel of irregular shape, the council may assume on behalf of the city such portion of the assessment as it may deem just.

The street railway company is required to pay the expense of paving on that portion of the streets between the outside rails of its tracks, but this obligation does not extend to all of the street car lines. On the so-called three-cent lines, comprising about one-third of the total mileage in the city,

the paving obligation was assumed by the city when the franchise was granted in 1894. Where the expense of paving is levied against the abutting property, the assessment rolls are made out in four parts and the assessments are payable in four yearly instalments. Any property holder, however, may pay the complete assessment at once. If he does not, he is charged seven per cent interest on the amount unpaid. If an assessment remains unpaid for thirty days after it is due a penalty of five per cent in addition to the interest is added. Assessments are collected by the receiver of taxes.

In Detroit as elsewhere there is considerable difference of opinion as to the value of different kinds of pavements. Cedar block pavement has been esteemed on residence streets on account of its cheapness. During the last few years the cedar block pavements have been laid with more care than formerly and it is hoped that they may prove satisfactory. Brick paving is preferred for streets where traffic is heavy.

In his exaugural address to the council on January 8th last, Mayor Codd recommended that for all new pavements and resurfacing cedar should be discarded. He favored asphalt or brick. The average cost of a new cedar pavement, according to Mayor Codd, was $2.14 per square yard, while the cost of sheet asphalt was $2.52, and of brick $2.47. In the case of repaving on six inches of concrete, the cost for cedar was $1.99 per yard; for sheet asphalt $2.33, and for brick $2.41.

The paving burdens sustained by the general fund of the City of Detroit are rather heavy. The appropriations last year were as follows:

For resurfacing and repairing	$398,029
For repaving	290,043
For paving intersections and concreting newly opened streets	75,500
	$763,572

This amount was paid by the city at large for paving, repairing and repaving streets. This amounts to more than two dollars per capita of population.

WASHINGTON, D. C.

By DANIEL E. GARGES, Secretary to the Engineering Commissioner, District of Columbia.

The letting of contracts for paving as well as for all other construction work in the City of Washington and District of Columbia, is regulated by the organic act under which the government of the District of Columbia was created by Congress, June 11, 1878. This act provides that whenever such construction work is to be done it shall be advertised. It further provides that where the amount involved is estimated at more than $1,000, the advertisement shall be inserted in a newspaper published in the City of Washington for one week, and where the sum exceeds $5,000, then in one newspaper in

each of the cities of New York, Philadelphia and Baltimore, as well as Washington. Specifications are prepared and sent to any prospective bidder upon request. Upon the date when the proposals are to be opened there is a public opening at which bidders are invited to be present. The law above referred to provides that the lowest responsible proposal for the kind and character of pavement or other work which the commissioners of the District of Columbia shall determine upon shall, in all cases, be accepted, provided, however, that the commissioners shall have the right, in their discretion, to reject all of such proposals. It is further provided by law that the successful bidder shall give a bond for the performance of his contract of not less than twenty-five per cent of the estimated amount of the contract, the percentage to be determined by the commissioners. This bond runs for five years from the date of the completion of the work, and in addition to this, on paving contracts, ten per centum of the cost of the work is retained for the same period of five years. This retent is held in the Treasury of the United States and may be invested by the Treasurer of the United States at the request of the contractor.

In the District of Columbia there are 138 miles of asphalt and coal-tar pavements, twenty-six miles of asphalt block pavement, twenty-six miles of granite or Belgian block pavement, and less than one mile of vitrified block pavement. We have no bitulithic or cedar block pavements.

The specifications require that the area over which the pavement is to be laid must be excavated to the proper depth below the surface and the space filled with good gravel, or other acceptable material, which must be rolled and rammed. Upon the bed thus prepared is laid a six-inch foundation of concrete made of one part Portland cement, four parts sand, five parts gravel and five parts broken stone. Upon this base there is laid a binder course one and one-half inches in thickness, after compression, and upon this again the asphalt wearing surface one and one-half inches after compression. The asphalt blocks are molded at a factory and delivered on the street, the size of the blocks being 5 x 4 x 12 inches. These are laid, generally, on a gravel bed five inches thick, when compacted, but in some cases are laid on a concrete base with sand cushion.

The asphalt mixture, both for the sheet asphalt and the asphalt block, must conform to certain specifications and tests, the laboratory tests being made by the inspector of asphalts and cements. The pavement is also subject to inspection while being mixed and while being laid. The contractors are held closely to the specifications, and the work must be accepted before payment. A time limit of completion is fixed, but the commissioners reserve the right to impose or waive this, and they may charge the cost of inspection at the rate of $4.00 per day, and also the sum of $10.00 per day, the latter as liquidated and fixed damages. The standard of work done in the District of Columbia is believed to be of the highest, and our specifications and methods have been copied in a number of municipalities.

The last contract let for laying sheet asphalt paving was $1.46 per square yard for the fiscal year 1906, and for asphalt block $1.76 per square yard for the fiscal year 1907. The price limited by law to be paid for sheet asphalt

paving during the fiscal year 1907 was $1.65 per square yard, but we were not able to obtain bids at or below this price. The limit was raised to $1.80 in the last appropriation act and bids are now being asked for. The limit for asphalt block is $2.00.

These prices are for the pavement proper. Other work incidental to laying the pavement is paid for at the following prices:

17. *Additional work.*—Contractors must do such additional work incident to the construction of new pavements as may be ordered on each street by the engineer commissioner. Prices paid for this work will be as stated below:

1. Removing old curb, including haul to the property yard, 8 cents per linear foot.
2. Hauling same beyond distance to nearest property yard, 1 cent per linear foot per mile.
3. Removing old rubble, cobble, flagging stone and brick, asphalt block, etc., including haul to the property yard, 15 cents per square yard.
4. Removing old granite block, including haul to the property yard, 20 cents per square yard.
5. Hauling same beyond distance to nearest property yard, 1 cent per square yard per quarter mile or fraction thereof.
6. Grading and hauling earth not to exceed 2,500 feet, 40 cents per cubic yard.
7. Grading and hauling macadam not to exceed 2,500 feet, 50 cents per cubic yard.
8. Removing old coal tar and bituminous base and hauling not to exceed 2,500 feet, 85 cents per cubic yard.
9. Removing old concrete base and hauling not to exceed 2,500 feet, $1.50 per cubic yard.
10. Hauling excavated material, per 100 feet, over first 2,500 feet, three-quarters of a cent per cubic yard.
11. Hauling from District property yard and setting 6 by 20 inch curb, 20 cents per linear foot.
12. Hauling from District property yard and setting 8 by 8 inch curb, 35 cents per linear foot.
13. Resetting 6 by 20 inch curb and 8 by 8 inch curb on old concrete base, 15 cents per linear foot.
14. Relaying vitrified brick or block on old concrete base, 60 cents per square yard.
15. Laying asphaltic, or bituminous, broken-stone base in place, $3 per cubic yard.
16. Laying and relaying asphalt and vitrified blocks on gravel base, 40 cents per square yard.
17. Adjusting manhole tops and basin covers to grade, $2 each.
18. Laying and relaying granite blocks, 75 cents per square yard.
19. Portland cement concrete base as specified herein, $6 per cubic yard.
20. Relaying cobble and rubble, 30 cents per square yard.
21. Dressing, jointing, and cutting curb, etc. (stonecutters' time), including setting-up labor, 65 cents per hour.
22. Repairing cement walks, $1.75 per square yard.
23. Repairing brick sidewalks, 20 cents per square yard.
24. Laying vitrified brick or block on 6-inch concrete base as specified, $1.30 per square yard.
25. Adjusting electric-light manholes to grade, as follows:
   (*a*) Size 14 by 14 inches, 75 cents each.
   (*b*) Size 18 by 15 inches, $1 each.
   (*c*) Size 36 by 26 inches, $1.50 each.
   (*d*) Size 6 by 6 feet, $4 each.

26. Resetting 8 by 8 inch curb on new concrete base, 31 cents per linear foot.

A vitrified block gutter is laid on each side of a street on which sheet asphalt pavements are laid, but not on a street paved with asphalt block.

The cost of paving roadways is defrayed by the municipality. The cost of curb and of setting same is divided between the municipality and the property owner, the latter paying according to his frontage on the street. He also pays half the cost of sidewalk.

Street railway companies are required to pay for the paving between their rails and tracks and for a space of two feet exterior to the outer rails of the tracks, and to maintain the same. Other public utility corporations only pay for repairing cuts they make in the pavements.

The amounts payable by the street railway companies are collectible and enforceable by a lien on their franchises. The amounts payable by property owners are enforced by special assessments which are a lien on the property and are payable in three instalments, the first within sixty days from notice and the other two in one and two years respectively, with interest at eight per cent on deferred payments. In default of payment the property is sold for taxes. No rebates are allowed for prompt payment.

The character of traffic on Washington streets is not heavy, and the use of sheet asphalt and asphalt blocks, which are practically the only kinds of improved pavements used, is very satisfactory. Granite or Belgian blocks are not deemed a satisfactory pavement on account of their noisiness.

Our method of letting contracts and of inspection has worked very satisfactorily and we have no recommendations for any improvements.

LOUISVILLE

By JAMES F. FAIRLEIGH, ESQ., Louisville, Ky.

The control of the streets of the City of Louisville rests in the board of public works. This board consists of three members appointed by the mayor. It has exclusive control over the construction, cleaning, and improving of all the streets and alleys of the city. No public highway can be opened, and no sidewalks can be constructed except by ordinance recommended by the board of public works. Whenever the board orders any work to be done, which is to be performed by independent contract, complete drawings and specifications are first prepared and placed on file in the office of the board. A notice is then inserted either in one daily or in one weekly newspaper of general circulation published in the city, at least once in each week for two weeks. This notice supposedly informs the public of the general nature of the work, of the fact that the drawings and specifications are on file, and of the nature and extent of the bond required. The board is required to let contracts to the lowest and best bidder. These contracts are, however, subject to the approval of the general council. The board has the power, in its discretion, to reject any and all bids. Bond is required, with approved security, for the faithful performance of the contract which is entered into.

When the improvement is the original construction of any street, it is made at the exclusive cost of the owners of lots in each fourth of a square, equally apportioned by the board of public works. Where the territory contiguous to any public way is not divided into squares by the principal streets, the ordinance providing for the improvement states the depth, not exceeding five hundred (500) feet, on both sides of the proposed improvement on which is to be assessed the cost, including the cost of the improvement of the street intersections. The original cost of improvement is a lien against the respective lots. The cost of making sidewalks, including curbing, whether by original construction or reconstruction, is apportioned by the front foot as owned by the parties fronting the improvement, except that each corner lot pays the cost of its sidewalk intersection. Property owners are given the right to improve public ways, if the majority of them petition the board of public works, but the improvement can only be allowed in the discretion of the board and must be made under its supervision. When the improvements are completed, the board of public works advertises by one insertion in a public newspaper the time and place for the inspection and reception of the work by the board, and owners may appear and be heard as to whether the improvements have been made in accordance with the ordinance authorizing the work and according to the contract.

The law specially provides for the enforcement of liens in courts, and sale of property and the right of redemption, etc. The right of redemption exists for a period of two years. A register is kept for indexing liens and payment of same.

The total mileage of paved streets, August 31, 1906, is as follows:

Asphalt	32.569	miles
Vitrified brick or block	51.341	"
Granite block	17.585	"
Macadam	69.809	"
Gravel	0.885	"
Boulder	8.339	"
Turnpikes (macadam)	4.460	"
Broken stone	3.081	"
Total	188.069	"

The soil is a sandy loam or clay which in itself makes a fairly good bed. Under all pavements is laid a six-inch foundation of concrete, of broken stone or screened gravel.

The inspection during the process of construction is rigid. An inspector visits each piece of work at least once a day, often four or five times a day. A supervisor is kept on the work during working hours from start to finish. The engineer sees the work whenever he can and always when necessary, and is in constant communication with the inspector and supervisor. Specifications are rigid and the contractor is held closely to them. The standard of work is consequently high. The time limit for completion is fixed by each

contract. Should the contractor fail to execute the work in the time stipulated, he forfeits his contract, and is entitled to no pay for the work done. The time fixed for the completion of the work may be and usually is extended by the board of public works for causes deemed sufficient.

The last letting of asphalt street paving was $1.97 per square yard, including a six-inch concrete foundation. The last letting of a vitrified brick or block street was at $1.58 per square yard; this includes a six-inch concrete foundation. Asphalt and granite have generally given more perfect satisfaction than other pavements.

MINNEAPOLIS

By Andrew Rinker, City Engineer, Minneapolis, Minn.

The City of Minneapolis lets no contracts for paving complete; the work is done by the city by day labor, under the direction and general charge of the city engineer. Contracts are made for materials or they are purchased in the open market, as is deemed best.

When material is advertised for, advertisements are inserted only in the official paper, and bids are received by the city clerk, who submits them, unopened, to the city council, which awards the contract. A bond (final) for the full amount of contract is required. Also the engineer may require a bond with the bid which varies generally from two per cent. to twenty per cent.

The following table shows the amount of pavement and its cost, January 1, 1907:

Variety	Sq. Yards in City.		Cost.
Asphalt	164,447	$421,698.44	
111,500 sq. yds. (approximately) resurfacing, 1906		167,381.46	
			$589,079.90
Brick	314,584		571,912.78
Creosoted blocks	224,192		585,999.59
Sandstone	296,118		648,110.75
Granite	238,270		661,133.48
Cedar blocks	256,809		263,058.80
Macadam	208,871		191,704.42
	1,703,291		$3,510,999.62

The above amounts include what is laid by the street railway company which paves and pays for that portion of the sweeping and sprinkling of the roadway between the outside rails of its tracks (15 feet). It is customary to require the same kind of paving as is laid on the remainder of the roadway. Twenty-one thousand square yards of the cedar block paving has been laid on concrete base within the past six years, at an average cost of $1.60; the remainder is practically worn out, having been laid many years ago, but has

served its purpose well as a cheap temporary pavement in a new and rapidly growing city. The character of the soil is, generally speaking, sand.

The required foundation for pavement is concrete, five inches thick; one part Portland cement, three parts sand, six to seven unscreened crushed limestone. The inspection work is in charge of general and sub-foremen. The material used, such as creosote oil, asphalt and cement, is tested by the city's chemist, who also sees that the required quantities of each are used. Contractors are held closely to specifications; for instance, creosoted blocks are required to be treated with fifteen pounds of the quality of oil specified, per cubic foot of wood; the city's chemist analyses the oil and sees that the quantity is used, measuring it from the storage tanks.

Work is paid for out of a permanent improvement and a permanent improvement revolving fund. The latter is a fund created for the purpose of advancing the amount assessable, which is paid back in five annual instalments with five per cent interest on deferred payment.

All assessable property is assessed for the cost of paving that part of the street on which the property abuts. The cost of paving all street intersections and parts along property exempt from special assessments is paid out of the permanent improvement fund, which is raised by general taxation, or bonds. Collections are made through the county treasurer's office, the same as regular taxes and then paid into the city treasury.

Wood block treated with creosoted oil is unquestionably the most satisfactory; it has the wearing qualities, it is noiseless and sanitary. In 1906 64,500 yards of this pavement were laid in Minneapolis at an average cost of $2.70 per yard. In 1906, 111,500 yards of asphalt were resurfaced at $1.50 per yard (contractors financing the scheme and receiving their pay, as far as assessable property is concerned, in five annual instalments with a ten-year guarantee surety company bond); 12,150 yards of brick on the same character of concrete as heretofore specified, were laid at an average cost of $2.17 per yard; 3,000 yards of sandstone were laid on concrete, at $2.74 per yard, and on sand, 12,000 yards at $2.05 per yard; 20,000 yards macadam (about one and one-half gallons of asphaltic surface binder per yard, were laid at $1.25 per yard. No cedar blocks were laid last year. The granite paving of last year was laid with old blocks removed from streets repaved with creosote blocks.

The United States Forestry Bureau, in conjunction with the city and interested paving contractors, laid on Nicollet Avenue, an experimental creosoted wood block pavement, consisting of various kinds of wood.

INDIANAPOLIS

By Jacob P. Dunn, Editorial Staff of *The Star,* Indianapolis, Ind.

Prior to 1888 the only street paving in Indianapolis was done with boulders, excepting a stretch of eight blocks on Delaware Street on which a trial was made of wooden blocks on a sand foundation; this soon became unsatisfactory and probably delayed a more general acceptance of modern paving. In 1888 about 20,000 square yards of tar macadam were laid, and in 1889 some

13,500 square yards more of this same material. It was known as "Filbert Vulcanite Asphaltic Pavement," and the standard was that laid on K Street, between Ninth and Nineteenth Streets, N. W., Washington, D. C. It was not very satisfactory, having such a tendency to soften in summer that it became popularly known as the "Yucatan" pavement. Nevertheless it was endured for ten years—part of it for twelve—and then resurfaced with asphalt. In 1890, 37,640 square yards were paved with Trinidad asphalt. In 1891 the new city charter was adopted, largely with a view to promoting public improvements, and since then street paving has progressed systematically. The results may be summarized as follows, up to January 1, 1907, the figures being for miles of streets and alleys in length, without regard to width:

Material	Mileage	Now under guaranty—Miles.	Cost.
Asphalt	47.86	17.5	$2,817,086.35
Asphalt resurfacing	3.93	....	233,161.43
Vulcanite	.15	....	.....
Brick	41.95	21.6	1,429,838.94
Creosoted pine blocks	14.84	15.9	1,134,143.59
Round cedar blocks	.54		
Creosoted cedar blocks	3.06		
Plain cedar blocks	1.86		
Macadam	8.03	4.34	268,594.17
Bitulithic	1.55	1.55	54,890.48
Total	123.77	60.89	$5,937,714.96

The cost per square yard varied considerably. In 1903 the city engineer estimated it at $2.10 for asphalt, $1.70 for brick, $2.80 for creosoted block, and $1.30 for macadam. In 1906 creosoted block was about $3.10, owing to the increased price of lumber. These figures do not include grading, but for asphalt, brick and block include a six-inch Portland cement concrete base. Up to 1896 all pavements were laid under a five-year guarantee. Since then the guarantee has been nine years, *i. e.*, the contractor keeps them in good repair for that period.

All contracts are made by the board of public works on sealed proposals, after due notice to property owners and advertisement. Specifications of advertisements must be strictly complied with and the bidder must deposit with his bid a certified check for two and one-half per cent of the estimated cost of the work. which is returned if the bid is not accepted, and held as security for contract if accepted. For repair guarantee the contractor deposits twenty cents per square yard during the continuance of the guaranty. The board reserves the privilege to reject any and all bids. Inspection is made by the city engineer's deputies, and is supposed to be strict. The time for completion varies with the contracts.

The cost of paving is paid by abutting property owners, including street intersections, except that the street railway company pays for paving between its tracks, and eighteen inches on each side. Assessments are made on front-

age, and are a first lien on the property. Under what is known as "the Barrett law" a property owner may take ten years to pay his assessment, in equal instalments, with six per cent interest on deferred payments. On taking the benefit of this law all legal objections are waived, and special improvement bonds are issued for the total amount of Barrett law claims on each improvement. These belong to the contractor, and are usually at a small premium, as they can be utilized for guaranty deposits and are treated as non-taxable.

For business streets brick has given the greatest satisfaction. Clay bricks are usually too soft, and shale brick too brittle, but the mixed clay and shale brick made at several points in Indiana is conceded to be very satisfactory. For residence streets preferences differ, though wooden block (creosoted) was generally favored until the price became so high. Asphalt and bitulithic also have warm advocates, especially among those who desire quiet. A comparatively small number prefer brick for residence streets, notwithstanding the noise. Macadam is used only on streets partaking of the nature of boulevards.

The total area of the city is 30.77 square miles, and the total length of streets and alleys 470.50 miles. The larger part of the streets and alleys are graded and graveled. The gravel streets are sprinkled in summer, and when kept in reasonable repair are very serviceable, the gravel of this vicinity being of excellent quality. The system of contracting for paving is fairly satisfactory, having been amended from time to time as cause appeared, and there is now no particular call for change in it.

HARTFORD

By Frederick Luther Ford, City Engineer, Hartford, Conn.

All contracts for city work exceeding in amount $500 are required to be publicly advertised, and the contract awarded to the lowest responsible bidder, who must furnish a satisfactory bond for the faithful performance of his contract. Each advertisement is published in one morning and one evening local daily paper. Upon such publication, a short notice not more than one and one-half inches in length, single column, stating the general nature of the full notice, and referring to it by name and date of the newspapers in which the original advertisement appeared, is published in one other daily morning paper, and one other daily evening paper.

The city is represented by the board of contract and supply which has authority to advertise for and receive bids, and to award contracts for all work to cost over $500, provided that the work is ordered by vote of the court of common council and if for improvements for which no assessment can be levied, provided any expenditure of over $10,000 is voted by the electors at a city meeting.

Sealed proposals for the work, on forms furnished by the city engineer, are received by the board of contract and supply up to a certain date specified in the advertisement and usually about one week in advance of publica-

tion. Each proposal is accompanied by a certified check for a given sum, as a guarantee that the bidder is acting in good faith. These checks are returned at once to the unsuccessful bidders, and to the successful one after he has executed the formal *contract* (not the work), and filed the required bond. The board of contract and supply reserves the right to reject any or all bids not deemed to the advantage of the city. The bond furnished must be in favor of the city, and executed by a surety company authorized to transact business within the state, having an agent in the city, and approved by the board of street commissioners. The amount is usually made for fifty per cent of the amount of the contract.

There have been laid in this city, pavements of sheet and block asphalt, Belgian blocks, creosoted wood (yellow pine) blocks, and a small area of vitrified brick. The wood block was laid by the street railway company, in opposition to the wishes of the city officials. The soil of Hartford, aside from the alluvial deposit of the Connecticut River, is a reddish clay, very susceptible to the action of frost, and therefore materially shortens the life of any pavement.

Foundations for improved pavements consist of a six-inch layer of 1-3-6 Portland cement concrete on a properly shaped and compacted subgrade. In the case of sheet asphalt, a binding course one inch in thickness is placed on the concrete foundation. This course consists of asphaltic cement and gravel, or fine crushed stone, fifteen gallons cement to one cubic yard stone, applied while hot and immediately rolled to the required thickness. On this is placed the wearing surface proper, which is rolled to a thickness of two inches. With block pavements a sand cushion one inch thick is interposed between the foundation and the blocks.

The city tries to get the best pavement possible under up-to-date methods. All work is under constant inspection by an assistant in the city engineer's office, delegated for that purpose. Contractors are held to the specifications, and required to guarantee their work and keep it in repair for a period of five years. The contractor in his proposal, states a maximum number of days in which he proposes to complete the work, and for every day occupied over and above such number, he agrees to forfeit and pay over to the city as liquidated damages, the sum of $20.00.

Original work, *i. e.*, first paving, is paid for as follows: The street railway company makes a separate contract for paving its share, which is a strip four feet wider than the width across the outer rails of single or double track, as the case may be. This work to be done at the same time, of the same materials, and in the same manner as the city's contract. The city does all the grading work in connection with the laying of pavements, and re-sets all curbing, water gates, sewer manholes, etc. Of the remainder the city pays one-third, and in addition the regular frontage assessment for all city property fronting on the street paved. The abutting property owners benefited pay the remainder. The cost of paving varies in different parts of the city. During the past ten years the cost of sheet asphalt has varied from $1.90 to $2.75 per square yard; block asphalt from $3.04 to $3.14 per square yard, and granite from $3.09 to $3.35. Most of the pavement laid is guaranteed for a

term of five years. The city at large pays for paving in front of all public parks, fire department houses, high school, city cemeteries, and all other city property. Repaving and repair work is paid for by the city at large.

No discounts or rebates are made on street paving assessments. All improved paving assessment bills are sent out by, and are payable to, the city collector. Liens are filed against all property where bills for improved pavement are not paid within three months from the completion and final acceptance of the work.

Sheet asphalt, on streets where grades are not too steep, has given best satisfaction. On grades of over three per cent Belgian block suits best.

DES MOINES

By E. D. SAMSON, ESQ., Des Moines, Iowa.

In the City of Des Moines, the proceeding for the pavement of a street is initiated by offering a proposed resolution in the council declaring the necessity or advisability of the improvement, stating the kind of material proposed, the method of construction and whether abutting property will be assessed for the cost. Notice of the time for considering the resolution must be given and the property owners may appear and object. Three-fourths of the council must vote in favor of the resolution, or it fails, unless the improvement has been petitioned for by the owners of a majority of the frontage affected, when a majority vote is sufficient. When this resolution is adopted the council may by resolution order the improvement made. The board of public works thereupon invites bids. Each bid must be accompanied by certified check as a guaranty for entering into a contract. The successful bidder is required to give a bond. The contract must require the contractor to keep the work in repair for at least one year after its completion. The bid of the lowest responsible bidder must be accepted unless all bids are rejected.

An inspector employed by the city is put over each set of workmen, who gives his whole time to the work of supervision and inspection. He may stop the work when it is not being done according to specifications, and discharge any workman who refuses so to do the work. A time limit for completion is always fixed, and liquidated damages of from three to five dollars a day are usually provided for, but the authorities are liberal in granting extensions, when reasonable so to do, and damages for delay have never been exacted. Contractors are held strictly to specifications, and a high standard of work is usually realized.

The first paving in the city was of cedar blocks which were later replaced with vitrified bricks, and afterwards these were in turn partly replaced by asphalt, that material being also used now for new paving.

The cost of cedar blocks was about $1.40 or $1.50 per square yard; bricks about $1.70 per square yard; asphalt about $2.00 per square yard, including in each case the foundation and the grading necessary to reduce the street from the established grade to the proper subgrade.

The cost including all incidentals such as advertising, surveying, inspec-

tion, etc., and cost of street intersections is assessed against abutting property according to benefits; except that in no case can more than twenty-five per cent of the value of any lot be assessed against it; and except as to payments by the street railway company as below. The city pays for no paving except that in front of its own property, and the excess of the twenty-five per cent limit of assessment against any lot.

The street railway company pays for paving seven feet in width in streets occupied by a single track, and fourteen feet in width upon any street or portion of street having a double track.

The property owner may, upon completion of the work, pay the assessment against him without rebate, or, if he choose, he may waive all objection to the assessment, and pay in seven annual instalments with six per cent interest. The assessments are certified by the city clerk to the county auditor, who in turn certifies them to the county treasurer for collection. They are a lien upon the property as are other taxes, and they are collectible in the same manner, including tax sale therefor if necessary.

Probably ten miles or more of cedar block paving were laid. It has all disappeared and has been replaced by brick or asphalt. There are at present in the city nine and one-fourth miles of asphalt paving, and seventy-one miles of brick. The cedar blocks proved unsatisfactory. The brick, of which we have a most excellent quality, and this being a center for their manufacture, have proved much better. Asphalt has been in use for only about seven years, but it promises to be more satisfactory than anything else thus far tried. However, the experimental stage is not yet passed. A recent order has been made for the paving of one business street with creosoted wooden blocks. No Belgian blocks have been laid. The method of procedure has been found quite satisfactory except upon the point of assessing the whole cost against abutting property. The present practice was begun when the city treasury's condition forbade any other. Property owners were in many cases willing to bear the whole expense in order to have paving, and the practice then adopted still continues.

DULUTH

By W. B. Patton, C. E., Manager Duluth Engineering Company, Duluth, Minn.

In the City of Duluth, Minn., no street paving can be done, except on a petition, signed by not less than twenty-five per cent of the property owners, owning at least twenty-five per cent of the property to be benefited. This petition is sent to the city council, and is, by it, referred to the board of public works, for investigation as to the sufficiency of the petition, the necessity of the improvement, and as to whether property can be found benefited to the cost of the work. The board reports back to the council, and that body orders the improvement made, and so instructs the board of public works. Based on the city engineer's estimate of the cost of the work, the board then proceeds to levy an advance assessment, equal to eighty per cent of the estimated cost, on the property to be benefited. Two public hearings

are given on the proposed assessment, after which it is confirmed by the board of public works, and sent to the city comptroller and treasurer for collection. The property owners have thirty days in which to appeal from the assessment to the district court. At the end of this period, ten days further are given for payment, at the expiration of which time, a penalty of ten per cent is added to all unpaid assessments, and they go over, with other city taxes, to the county treasurer, for collection. As soon as the amount paid on the advance assessment, plus the amount on hand in the permanent improvement revolving fund, equals the estimated cost of the work, and not before the board of public works advertises for bids with six days' notice in two publications. The bids are opened in public, and tabulated by the board of public works, and the contract awarded to the lowest responsible bidder, subject to the approval of the city council.

In cases where bids are asked on more than one material for paving, a meeting of the interested property owners is usually called by the board to ascertain their preference. The board then recommends a material to the council, with its award of the contract, and interested parties can obtain a hearing before the council, if they so desire. It is customary to abide by the expressed wishes of a majority of the property owners, but the charter gives to the council the right to designate the material. Each bidder is required to accompany his bid with a certified check for ten per cent of the amount of the same, and the successful contractor is required to give a surety company bond for the full amount of his contract. The law requires the contract to be awarded to the lowest responsible bidder.

The materials used at present are: Asphalt, bitulithic, brick, creosoted wood blocks, sandstone blocks, tar and Telford macadam. Gravel and cedar blocks were formerly much used, but no new improvements are being made with these materials, except that gravel is used on some outlying and otherwise little-used streets.

Since 1900, including work under contract, these different materials have been used in the following amounts:

Asphalt	29,328	square	yards
Bitulithic	9,844	"	"
Brick	48,910	"	"
Creosoted wood blocks	17,740	"	"
Sandstone blocks	47,304	"	"
Tar macadam	109,259	"	"
Telford macadam	13,559	"	"

The soil of Duluth is, almost universally, a stiff, red clay; in some districts, however, sand occurs, asphalt, creosote blocks and bricks are always laid on concrete; sandstone blocks are sometimes laid on concrete, and at other times on sand. Bitulithic and tar macadam have, so far, been laid on broken stone four inches to six inches in thickness.

Contract work is under the supervision and control of the city engineer, who appoints all inspectors and removes them at his pleasure. Every effort is made to secure the carrying out of the contract according to its terms,

and the standard of work is high, and the execution is generally of a very satisfactory character. Liquidated damages, for failure to complete work on time, are fixed in each contract. The amount varies from ten dollars to twenty-five dollars per day, according to the amount and importance of the work. These damages are seldom collected, as extensions of time are generally granted by the council, unless the contractor has been grossly negligent.

The latest prices on the several materials are as follows:

	Per sq. yd.
Asphalt (on 5-inch Portland cement concrete)	$2.05
Bitulithic	1.70
Brick	2.00
Creosoted blocks (on 3-inch Portland cement concrete)	2.30
Sandstone blocks (on 6-inch Portland cement concrete)	3.00
Sandstone blocks (on sand)	2.00
Tar macadam	1.30
Telford macadam	1.00

All these prices are for the paving and foundation, but do not include any excavation, curbing or similar work, all of which are paid for separately.

At the completion of the work the difference between the actual cost and the advance assessment, including all incidental work, is assessed against the abutting property in accordance with the benefits, which practically amounts to a frontage basis on the streets on which the lots face. For the cross avenues the cost is spread over the lots for one-half the distance between the avenues on each side, decreasing in amount as the lots are more distant from the improvement. The city pays no part of the cost, except for abutting public property or the property of corporations, which, by state law, pay a gross earnings tax, which by decision of the Supreme Court, has been held to include special assessments, although no part of the tax is received by the city, the entire amount going into the state treasury.

The street railway pays no part of the cost of paving where its tracks occupy the street, except the extra cost made necessary by the presence of its rails in the streets. This amounts, at a maximum, to fifty cents per square yard, for the paving lying between, and one foot outside of the rails.

The various materials mentioned have all given satisfaction under the conditions in which they have been used. For the streets in the wholesale districts, and the steep avenues in the business portion, where the traffic is heavy, sandstone blocks are generally used, while under lighter traffic, and on even much steeper grades, as high as fourteen per cent bitulithic and tar macadam have proven satisfactory. For the larger number of streets, both residence and business, tar macadam is at present the favorite material. This pavement is built under specifications prepared by the city, and is equal in all respects to bitulithic. In order to secure competition the city purchased a mixing plant, which it rents to the contractors on reasonable terms. The result of this movement has been to reduce the cost of tar macadam, and with it all the other kinds of paving, as tar macadam is one of the materials on which bids are asked in almost every case, and its cheapness and desirability make it a strong competitor.

GENERAL SUMMARY IN DOLLARS OF COST PER SQUARE YARD OF PAVING IN CITIES OF THE UNITED STATES.

	New York.*	Chicago.†	Philadelphia.*	St. Louis.*	Boston.‖	Baltimore.‖	Cleveland.‖	Buffalo.‡	Cincinnati.*	Detroit.‡	Washington.*	Louisville.‖	Minneapolis.‖	Indianapolis.§	Hartford.*	Des Moines.‖	Duluth.‖
Asphalt sheet	1.66[1]	....	1.56[1]	....	....	1.92[2]	....	....	....	2.52[2]	1.46[2]	....	....	....	1.90[2]	....	....
Asphalt block	2.36[1]	....	....	....	....	2.13[2]	....	....	....	....	1.76[2]	....	....	....	3.04[2]	....	....
Asphalt, not specified	....	2.20[3]	....	1.60[4]	3.75[2]	....	2.25[2]	2.56[1]	2.35[3]	....	....	1.97[3]	....	2.10[3]	....	2.00[2]	2.05[4]
Belgium block	....	....	....	....	....	2.85[1]	....	....	....	....	....	....	....	....	....	....	....
Granite block	3.55[1]	3.75[3]	2.91[1]	2.60[3]	4.75[2]	....	....	....	4.00[3]	....	....	....	....	....	3.09[2]	....	....
Bitulithic	....	....	3.00[1]	2.15[3]	3.50[2]	2.15[2]	....	....	2.50[2]	....	....	....	....	....	....	....	1.70[2]
Brick (vitrified)	....	2.45[3]	1.68[1]	1.70[3]	....	2.00[2]	1.40[1]	....	....	2.47[2]	....	1.58[3]	2.17[4]	1.70[3]	....	1.70[2]	2.00[1]
Creosoted wood blocks	4.45[1]	3.25[3]	....	....	4.25[2]	....	....	....	3.75[3]	....	....	....	2.70[4]	3.10[3]	....	....	2.30[5]
Cedar blocks	....	....	....	....	....	....	....	....	....	2.14[2]	....	....	1.60[2]	....	....	1.40[2]	....
Concrete	....	2.50[6]	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Macadam (general)	....	1.25[6]	....	....	1.00[2]	....	....	1.83[2]	1.25[6]	....	....	....	1.25[4]	1.30[2]	....	....	....
Telford macadam	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.00[1]
Tar macadam	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.30[2]
Medina stone	....	....	....	....	....	....	3.15[3]	3.43[1]	....	....	....	....	....	....	....	....	....
Novaculite	....	1.25[2]	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Sand stone blocks	....	....	....	....	....	....	....	....	....	....	....	....	2.74[4]	....	....	....	3.00[3]

Foundation:—[1] Concrete or other base not specified. [2] Not reported. [3] 6-inch cement concrete. [4] 5-inch cement concrete. [5] 3-inch cement concrete. [6] Cinder, stone or other base above 10 inches.

* Guarantee five years. † Guarantee five to ten years. ‡ Guarantee ten years. § Guarantee nine years. ‖ No guarantee reported.